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# INCANDESCENT LAMPS: Their Use and Abuse.

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COMPLIMENTS OF

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# INCANDESCENT LAMPS:

## THEIR USE AND ABUSE.

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In the present state of the art of incandescent lighting, in no way can Central Station Managers increase the efficiency of their investment more than by careful study of ways and means of operating lamps in a manner which will insure an average maximum light for a minimum expenditure.

Too large a percentage of Central Stations judge the quality of lamps sold them almost entirely by their life, and even that poor basis of calculation is still further distorted by keeping no ampere records nor averaging results, but judging solely by the individual records of such lamps as may fail in the first hundred hours, or of those which live hundreds of hours past the point, at which, from an economical standpoint, they should have been broken. The importance to Central Station Managers of judging lamps which are sold to them from some better basis than individual or even average life, can be better appreciated by referring to Diagram No. 1, showing curves of deterioration in candle power of lamps manufactured by different companies. (In considering deterioration in candle power, it should be stated that it is a characteristic of every lamp which has yet been manufactured and should be considered entirely independent of blackening or discoloration of the bulb. Lamps may deteriorate to 50 per cent. of their initial

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candle power within two hundred hours, and still show scarcely a trace of blackening.) All lamps, the curves of which are shown, were purchased within six months in the open market in lots of from ten to twenty-five, and the curves are the average result obtained by starting each lamp at the particular voltage which would bring the lamp to exactly 3 watts per candle, maintaining the voltage constant throughout its life.

Curves Nos. 3, 5 and 6, Diagram No. 1, represent the best results obtained from the product of numerous foreign manufacturers. Nos. 4, 8, 9, 10, 11 and 12 each represent a different domestic manufacturer.

While there is no reason to suppose that the average life of lamps shown by Nos. 4 and 7 will be shorter than that of lamps represented by curves Nos. 10, 11 and 12, there is also no certainty that it will be longer, and if a lamp is to be branded as poor by the Central Station Manager, because of the breakage of a small percentage of lamps in the first one hundred hours, then the advantage is in favor of the lamp which reached 50 per cent. of its original candle power in the first two hundred hours, thus maintaining the carbon at a high degree of incandescence with the necessarily greater strain of the filaments for only a few hours.

The carbon which maintains its candle power must continue to burn at a higher temperature, nearer the point of vaporizing and is more likely to be destroyed by an abnormal increase in pressure than one which cools within the first few hours to a point where considerable increase in voltage is required to bring it to its initial degree of heat or incandescence.

From the standpoint of the Central Station, one of the worst guarantees that you could demand from the lamp manufacturer would be an individual life (for each lamp) of one or two hundred hours. The reason for



such demand, when made on your part, arises from the erroneous impression that the lamp which lives only one or two hundred hours is necessarily defective. Nearly every lamp sold you, and particularly those which show the best results, rises in candle power for the first few hours (this is not shown in Diagram No. 1, as in only one case was the first test after the lamps were started made before the candle power commenced to drop).

On nearly every Central Station, particularly on alternating current stations, during light load, the pressure on the primary is abnormally high. Add to this the difference between drop in the transformers and secondary wiring, as between full and light load, and the result which a test is quite certain to show, is pressure on the one or two lamps which the customer is burning during light load from 6 to 8 per cent. high.

Referring to Diagram No. 2, we find that burning a new 16 c. p.  $3\frac{1}{2}$  watt lamp 7 per cent. high would, for the first few hours, raise its candle power to 25 and its efficiency to about 2.6 watts per candle. In less than one hundred and fifty hours, even maintaining the high pressure mentioned, the candle power and efficiency would fall below normal; but in the meantime, the new lamps which have been burned under the above conditions have been abused to an extent which would be quite certain to make the showing of some individual lamps very poor, *through no fault of the lamps.*

After lamps have been in use about two hundred hours, under average conditions, they could then be used where the pressure was high, without bringing the carbon to a dangerous degree of incandescence.

One of the best illustrations I can give of the importance of your judging lamps from some better standard than simply life, is to refer to an incident of which I had reliable information where a representative

of the Lamp Company, who manufactured the lamps shown by Curve No. 12, Diagram No. 1, exhibited the valuable quality possessed by his lamp standing very high pressure. With a rheostat it was exhibited burning from normal to a very high candle power. He represented it as the *toughest* filament ever placed in a lamp, and I have no cause to disbelieve him.

If Central Stations run with a variation of from 6 to 20 per cent. in pressure they will find it necessary to demand *tough* lamps, the natural product of the *amateur* lamp manufacturer. To bring a product up, however, even from Curves Nos. 9, 10 and 11 to No. 4, means experience and thousands of dollars spent in experiments.

It also means that each one of over fifty different operations through which the parts of a lamp pass from start to finish, should receive careful, intelligent handling or direction. Perfection in any one particular will not attain even average results.

The manufacturer of lamps shown by Curve No. 4 might have furnished the same carbons to manufacturers of lamps represented by Curves Nos. 10 and 11, and the result which they would obtain would not differ materially from that secured with their own make of carbons. Curve No. 4, though it represents as high an average grade of lamp of any voltage above 100 as has yet been furnished to the customers of any lamp manufacturer, does not represent the highest point which will be attained.

Curves Nos. 1 and 2 represent experimental lamps manufactured and furnished for test by the same company, whose regular product is represented by Curve No. 4, and I am informed by reliable experts that within a few months the entire product of the company will be brought up to the standard represented by Curve No. 1.

That the relative value of the lamps represented by these curves may be fully appreciated, let us take the



average candle power of Curve No. 1, Diagram No. 1, which for six hundred hours is 1419 candles and we find, to maintain the same average candle power, using other lamps, we should have to break lamps represented by Curve No. 4, at five hundred and thirty hours; No. 7 at one hundred and seventy hours; No. 8 at one hundred hours; No. 9 at one hundred and twenty hours; No. 10 at ninety hours; No. 11 at seventy-five hours, and No. 12 at thirty-five hours.

All of the lamps represented by Diagram No. 1 are of voltages from 100 to 125 volts, and though started at a higher economy (vs. 5 watts per candle) than is commonly practiced by Central Stations (the 3.1 standard of Edison Illuminating Companies being the highest of which I have personal knowledge). Testing at 3 watts comes nearer to results obtained by commercial practice than a lower initial economy, as the tendency of the average Central Station is to run high.

Diagram No. 3 represents lamps of from 50 to 60 volts, started at 3 watts per candle, and tested under the same conditions as the 100 to 120 volt lamps.

No. 1 is the product of the same factory as Nos. 1, 2 and 4, Diagram No. 1.

No. 2 was manufactured by the same company as No. 9.

No. 3 was manufactured by the same company as No. 11.

No. 4 was manufactured by the same company as No. 10.

As proven by these curves, and also, I believe, as generally acknowledged, it is much easier to produce a fairly good 50 volt lamp than one of a voltage above 100; but, considering the progress which has been made within the past year in the high-volt lamps, I believe that in a short time a large percentage of alternating

current Central Stations will find it to their advantage to use large transformers and secondary mains on the three-wire system, covering one or more blocks from one transformer or bank of transformers and using only lamps of over 100 volts, thus greatly economizing in copper and securing much better regulation than is now secured with numerous small transformers and 50 volts on the secondary.

The importance of good regulation or a constant voltage at the lamps is too little appreciated, the general opinion of Central Station managers apparently being that so long as the life of the lamp is satisfactory to themselves or their customers, if they increase the voltage either temporarily or permanently, the result would be to increase the average light. The facts are that burning lamps above their normal rating decreases the entire average candle power on the customers' circuits and at the same time, if the station is on a meter basis, increasing the amount of the customers' bills. The above statement is particularly true of lamps only of average quality.

Referring to Diagram No. 2, No. 5 curve represents a 108 volt, 16 c. p.,  $3\frac{1}{2}$  watt lamp burned at a constant voltage and reaching 11 candles at five hundred hours, starting the same lamp at 110 volts or at  $17\frac{1}{2}$  candles, 3.3 watts per candle, and inside of two hundred hours the candle power curve crosses the one burned at normal. Starting it at 112 volts or at  $19\frac{1}{2}$  candles, 3.1 watts per candle, in less than two hundred hours the candle power curve crosses both the others.

Curves Nos. 1 and 2, follow the same general law. The higher we raise the voltage the more rapid the drop in candle power, and when we consider that the lamp represented by Curve No. 1 *must be kept at 116 volts* in order to give 14 candles of light after two hundred hours,



and that should the voltage be brought back to normal or 108 volts, the candle power would be only about 9 candles, we can appreciate that on a station where the voltage varies even 7 per cent., the result must be a very uneven and poor quality of light, even though the *life* of the lamp is satisfactory.

The tendency of all Central Stations seems to have been to gradually raise their voltage with the intention of thus either burning out or increasing the candle power of the old lamps on their circuits. The result is only to either burn out an abnormal number of new lamps or bring them down to the candle power level of the old ones within two hundred hours.

The only practical method of keeping the average candle power of lamps on a station at a point which will be satisfactory to customers or on a competitive basis with other methods of lighting, is to keep records of the average life on the entire station where free renewals are furnished, and then to take out of the sockets and break up all lamps which are dim, by this means keeping down the average life to whatever constant is decided as the best under local conditions. Where lamps are sold to customers, to keep the candle power of lamps in use on the circuit of a Central Station at a point which will insure satisfaction or tend to keep the electric light popular, is a difficult problem. Whether the customer is on a meter or on a contract basis, it is poor economy for him to keep lamps in his sockets which are giving only 50 per cent. of their initial candle power, but for the corporation which sold him the lamps and supply him with current, to call his attention to the fact that lamps in his sockets are giving only about 8 candles, and attempt to sell him lamps at 50 or 60 cents each, is not likely to bring about the desired result. To meet the above difficulties a number of Central Stations in

different parts of the country are now selling lamps at retail to their customers at cost and a few stations even below cost, at the same time doing all in their power to prove to them that only by a liberal use of lamps can they obtain the greatest amount of light for a given expenditure of money.

As the profit on the sale of lamps is decidedly a secondary matter as compared to the sale of current and the increased quality of the light, the above plan should commend itself to all Central Stations not on the basis of furnishing free renewals. It is also worthy of consideration that by adopting the above plan the station controls what lamps shall be used on its circuits without dictating to its customers; an important point, while lamps show such widely different results as those shown by Diagram No. 1, and while customers continue more likely to believe that the corporation is not supplying proper current, than to believe that the quality of lamps they have been purchasing is at fault.

Another method of inducing customers to destroy dim lamps which has found favor with a number of stations is to make a price for lamps of say 40 cents each and agreeing with their customers to exchange all dim lamps (which they have sold them) at half price, that is, for every dim lamp which the consumer returns before the carbon is burned out, he receives a new lamp for 20 cents.

Within the past few months the question has often been asked me by Central Station Managers, "What economy of lamps should we use?" This question should, I believe, be settled by Central Station Managers themselves on presentation of facts, they having control of the regulation of their station and knowledge of local conditions.

Diagram No. 4 shows the same quality of lamp manufacture as Curve No. 2, Diagram No. 1, and repre-



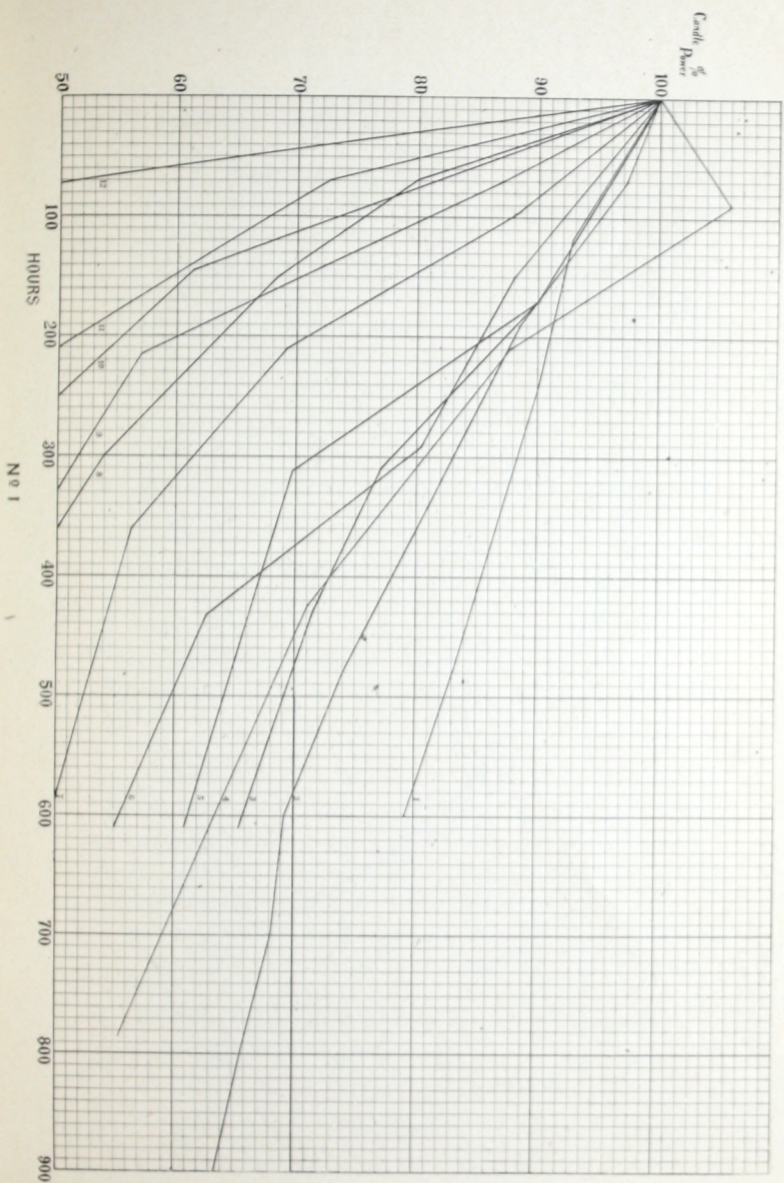
sents 16 c. p. lamps started at an initial economy of 4, 3½, 3 and 2½ watts per candle. The accompanying table shows candle power, average candle power, average economy and average candles per electrical horse power at one hundred hour periods in their life.

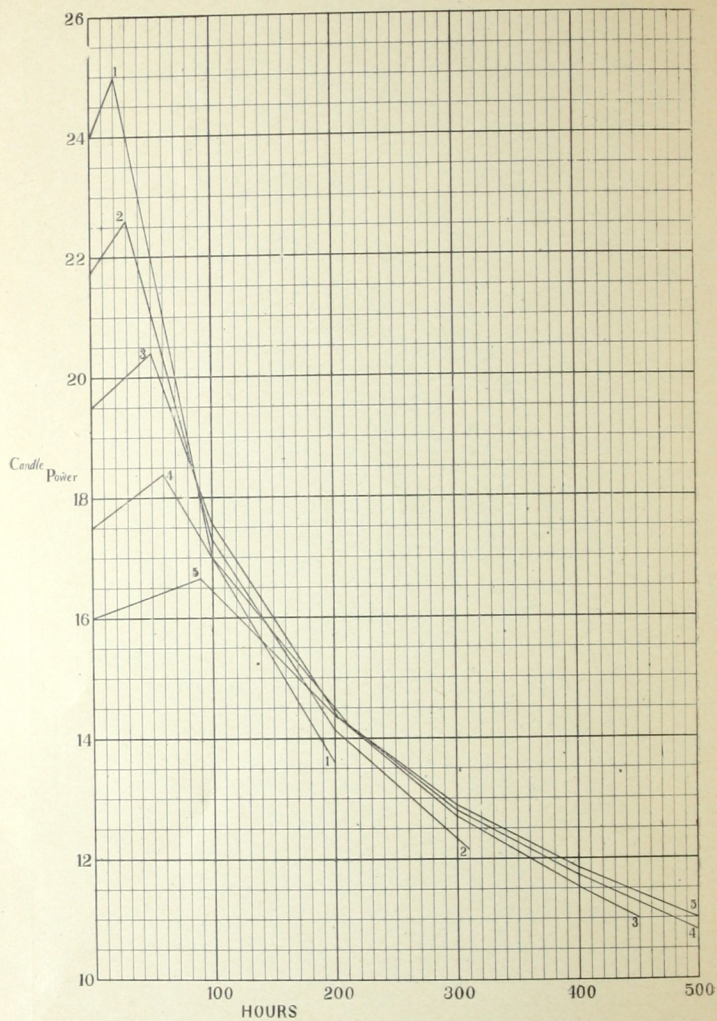
In considering these curves and table it should be remembered that the result would have been much less favorable to the higher economy lamps had the test been made and the curves plotted with a poorer quality of lamp, and also that satisfactory results with lamps of higher economy than 3½ watts per candle can only be obtained by exercising the greatest care in maintaining a constant voltage at the lamps. Referring to the table briefly, it will be found that even at six hundred hours, lamps of the highest initial economy show the best average result as to average watts per candle and average candles per horse power. And that at nine hundred hours 3 watt lamps show better average results than lamps of 3.6 or 4 watts. The greatest objection which can be urged against the high economy lamp is that while at nine hundred hours the 4 watt lamp reaches a minimum candle power of 13¼ candles and the 3½ watt lamp about 12 candles, the 3 watt lamp reaches 10 candles and the 2½ watt lamp at six hundred hours reaches 8 candles. At the present price of lamps, where fuel is high and the customers' bills are made up on the basis of lamp hours, it would, without question, pay the station to use high economy lamps, breaking them at a point which would insure satisfaction as to average light and keeping the average life comparatively short.

Whatever economy or make of lamp you decide to use, by no means can you so greatly increase the efficiency of your station as by making every possible effort in the direction of maintaining a constant voltage at the lamps. This can only be accomplished and maintained

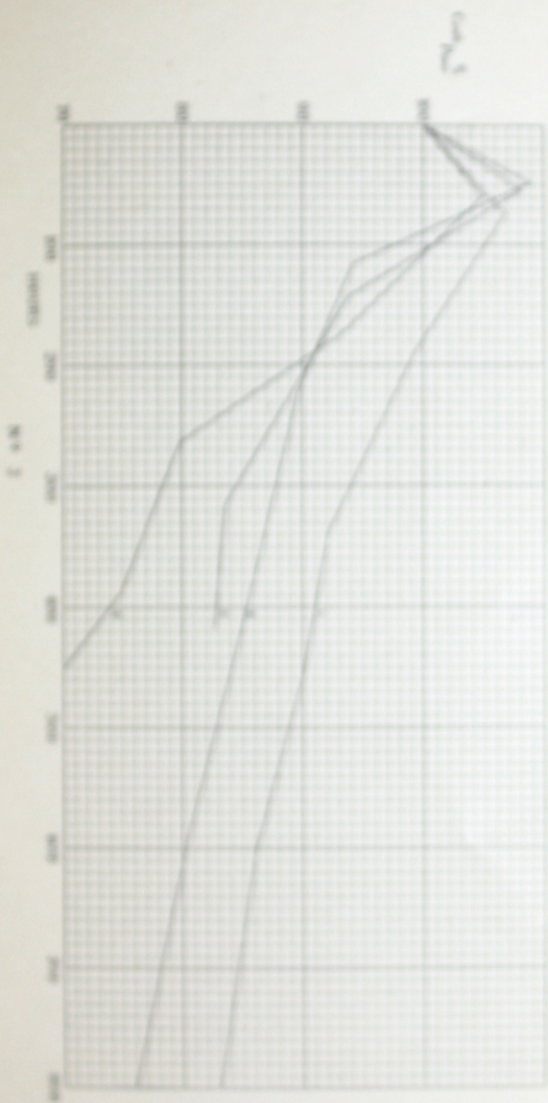
by constant use of reliable, portable instruments. No switchboard instrument should be relied on, without often checking it by some reliable standard, and it should also be borne in mind that, owing to the varying drop at various loads, constant voltage *at the station* is just what is not wanted. If you do not possess a reliable, portable volt-meter, such an instrument should be your next purchase, then by constant use on your circuits at different loads and *profiting by the knowledge thus obtained*, you would soon find a marked improvement in your lighting and would be in a position to judge which make and what economy of lamp is the best for you to purchase.

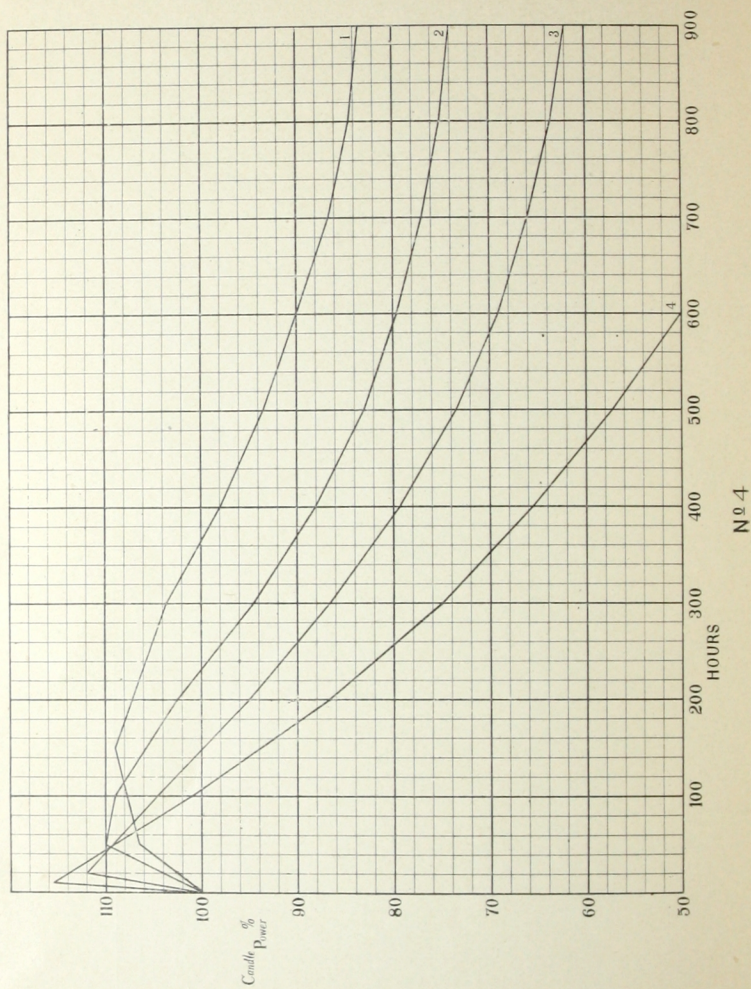














	64 Watts	56 Watts	48 Watts	40 Watts
<i>100 Hours</i>				
<i>C.P.</i>	17.28	17.44	16.8	16.16
<i>Average C.P.</i>	16.8	17.06	17.09	16.90
<i>Average Watts Per Candle</i>	3.9	3.28	2.8	2.36
<i>Candles Per E.I.E.P.</i>	191	227	266	316
<i>200 Hours</i>				
<i>C.P.</i>	17.12	16.32	15.2	14.08
<i>Average C.P.</i>	17.03	16.94	16.71	15.97
<i>Average Watts Per Candle</i>	3.76	3.3	2.9	2.5
<i>Candles Per E.I.E.P.</i>	198	226	257	295
<i>300 Hours</i>				
<i>C.P.</i>	16.64	15.04	13.92	12.
<i>Average C.P.</i>	16.06	16.53	15.66	14.90
<i>Average Watts Per Candle</i>	3.77	3.39	3.03	2.67
<i>Candles Per E.I.E.P.</i>	199	220	240	279
<i>400 Hours</i>				
<i>C.P.</i>	15.68	14.08	12.8	10.56
<i>Average C.P.</i>	16.74	16.	15.2	14.03
<i>Average Watts Per Candle</i>	3.82	3.5	3.16	2.85
<i>Candles Per E.I.E.P.</i>	195	211	236	262
<i>500 Hours</i>				
<i>C.P.</i>	15.	13.28	11.68	9.12
<i>Average C.P.</i>	16.45	15.57	14.62	13.2
<i>Average Watts Per Candle</i>	3.89	3.59	3.25	3.03
<i>Candles Per E.I.E.P.</i>	192	208	227	246
<i>600 Hours</i>				
<i>C.P.</i>	14.40	12.8	11.04	8.
<i>Average C.P.</i>	16.	15.15	14.08	12.43
<i>Average Watts Per Candle</i>	4.	3.7	3.41	3.22
<i>Candles Per E.I.E.P.</i>	187	202	219	232
<i>700 Hours</i>				
<i>C.P.</i>	13.92	12.32	10.56	
<i>Average C.P.</i>	15.84	14.76	13.63	
<i>Average Watts Per Candle</i>	4.04	3.79	3.52	
<i>Candles Per E.I.E.P.</i>	185	197	212	
<i>800 Hours</i>				
<i>C.P.</i>	13.6	12.	10.24	
<i>Average C.P.</i>	15.6	14.45	13.23	
<i>Average Watts Per Candle</i>	4.1	3.88	3.62	
<i>Candles Per E.I.E.P.</i>	182	192	206	
<i>900 Hours</i>				
<i>C.P.</i>	13.28	11.84	9.92	
<i>Average C.P.</i>	15.36	14.10	12.88	
<i>Average Watts Per Candle</i>	4.17	3.94	3.73	
<i>Candles Per E.I.E.P.</i>	179	189	200	